CHARUSAT
CHAROTAR UNIVERSITY OF SCIENCE AND TECHNOLOGY

CE266: SOFTWARE ENGINEERING

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UNIT 7

Quality Assurance and Management

DEPSTAR

Content

- Quality Concepts and Software Quality Assurance
- Software Reviews (Formal Technical Reviews)
- Software Reliability
- The Quality Standards: ISO 9000, CMM, Six Sigma for SE
- SQA Plan

Quality Concepts

- In 2005, *ComputerWorld* [Hil05] lamented that
  - "bad software plagues nearly every organization that uses computers, causing lost work hours during computer downtime, lost or corrupted data, missed sales opportunities, high IT support and maintenance costs, and low customer satisfaction.
- A year later, *InfoWorld* [Fos06] wrote about the
  - "the sorry state of software quality" reporting that the quality problem had not gotten any better.
- Today, software quality remains an issue, but who is to blame?
  - Customers blame developers, arguing that sloppy practices lead to low-quality software.
  - Developers blame customers (and other stakeholders), arguing that irrational delivery dates and a continuing stream of changes force them to deliver software before it has been fully validated.

Quality

- The *American Heritage Dictionary* defines *quality* as
  - "a characteristic or attribute of something."
- For software, two kinds of quality may be encountered:
  - Quality of design encompasses requirements, specifications, and the design of the system.
  - Quality of conformance is an issue focused primarily on implementation.
  - User satisfaction = compliant product + good quality + delivery within budget and schedule

Quality—A Philosophical View

- Robert Persig [Per74] commented on the thing we call *quality*:
  - Quality . . . you know what it is, yet you don't know what it is. But that's self-contradictory. But some things are better than others, that is, they have more quality. But when you try to say what the quality is, apart from the things that have it, it all goes poof! There's nothing to talk about. But if you can't say what Quality is, how do you know what it is, or how do you know that it even exists? If no one knows what it is, then for all practical purposes it doesn't exist at all. But for all practical purposes it really does exist. What else are the grades based on? Why else would people pay fortunes for some things and throw others in the trash pile? Obviously some things are better than others . . . but what's the betterness? . . . So round and round you go, spinning mental wheels and nowhere finding anyplace to get traction. What the hell is Quality? What is it?

Quality—A Pragmatic View

- The *transcendental view* argues (like Persig) that quality is something that you immediately recognize, but cannot explicitly define.
- The *user view* sees quality in terms of an end-user's specific goals. If a product meets those goals, it exhibits quality.
- The *manufacturer's view* defines quality in terms of the original specification of the product. If the product conforms to the spec, it exhibits quality.
- The *product view* suggests that quality can be tied to inherent characteristics (e.g., functions and features) of a product.
- Finally, the *value-based view* measures quality based on how much a customer is willing to pay for a product. In reality, quality encompasses all of these views and more.

Software Quality

- Software quality can be defined as:
  - *An effective software process applied in a manner that creates a useful product that provides measurable value for those who produce it and those who use it.*
- This definition has been adapted from [Bes04] and replaces a more manufacturing-oriented view presented in earlier editions of this book.

Effective Software Process

- An *effective software process* establishes the infrastructure that supports any effort at building a high quality software product.
- The management aspects of process create the checks and balances that help avoid project chaos—a key contributor to poor quality.
- Software engineering practices allow the developer to analyze the problem and design a solid solution—both critical to building high quality software.
- Finally, umbrella activities such as change management and technical reviews have as much to do with quality as any other part of software engineering practice.

Useful Product

- A *useful product* delivers the content, functions, and features that the end-user desires
- But as important, it delivers these assets in a reliable, error free way.
- A useful product always satisfies those requirements that have been explicitly stated by stakeholders.
- In addition, it satisfies a set of implicit requirements (e.g., ease of use) that are expected of all high quality software.

Adding Value

- By *adding value for both the producer and user* of a software product, high quality software provides benefits for the software organization and the end-user community.
- The software organization gains added value because high quality software requires less maintenance effort, fewer bug fixes, and reduced customer support.
- The user community gains added value because the application provides a useful capability in a way that expedites some business process.
- The end result is:
  - (1) greater software product revenue,
  - (2) better profitability when an application supports a business process, and/or
  - (3) improved availability of information that is crucial for the business.

Quality Dimensions

- David Garvin [Gar87]:
  - **Performance Quality.** Does the software deliver all content, functions, and features that are specified as part of the requirements model in a way that provides value to the end-user?
  - **Feature quality.** Does the software provide features that surprise and delight first-time end-users?
  - **Reliability.** Does the software deliver all features and capability without failure? Is it available when it is needed? Does it deliver functionality that is error free?
  - **Conformance.** Does the software conform to local and external software standards that are relevant to the application? Does it conform to de facto design and coding conventions? For example, does the user interface conform to accepted design rules for menu selection or data input?

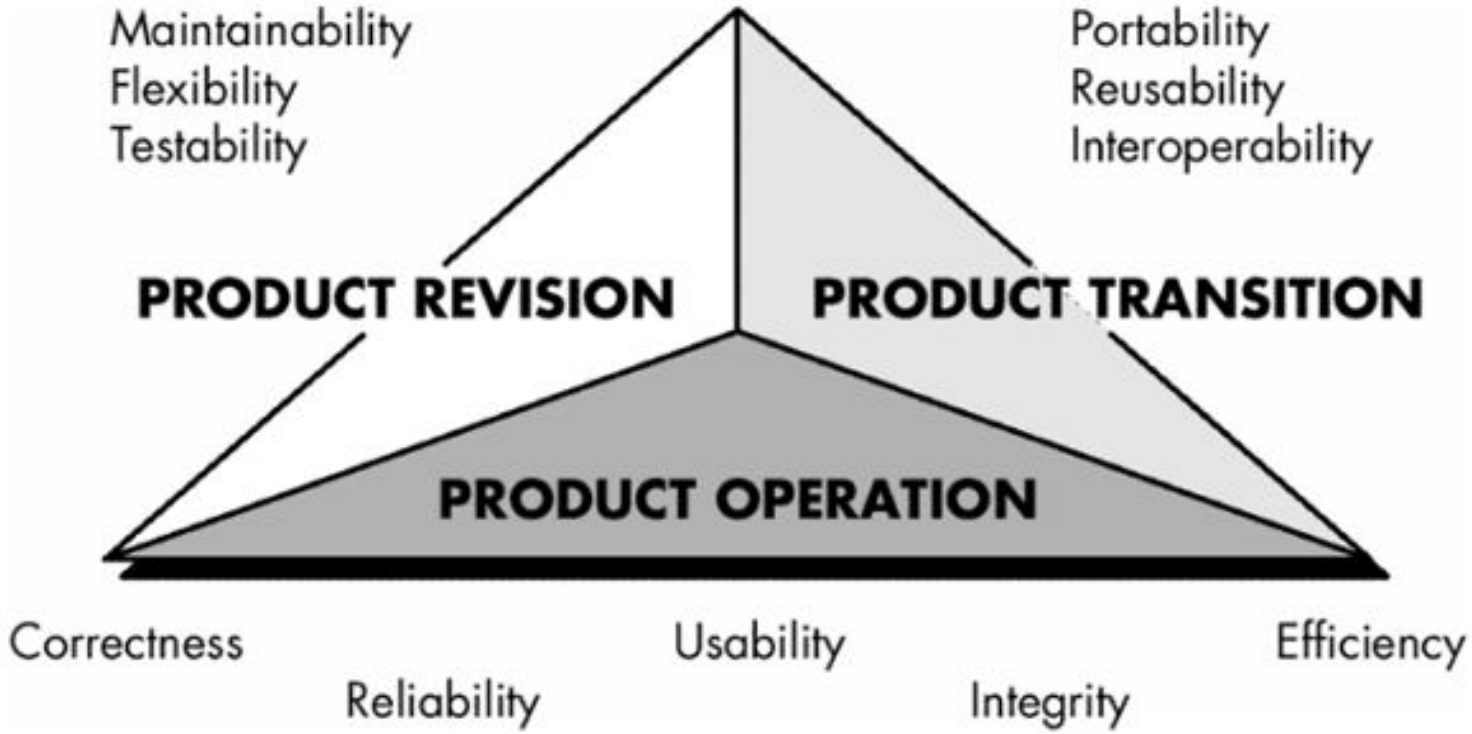
Contd…

- **Durability.** Can the software be maintained (changed) or corrected (debugged) without the inadvertent generation of unintended side effects? Will changes cause the error rate or reliability to degrade with time?
- **Serviceability.** Can the software be maintained (changed) or corrected (debugged) in an acceptably short time period. Can support staff acquire all information they need to make changes or correct defects?
- **Aesthetics.** Most of us would agree that an aesthetic entity has a certain elegance, a unique flow, and an obvious "presence" that are hard to quantify but evident nonetheless.
- **Perception.** In some situations, you have a set of prejudices that will influence your perception of quality.

Other Views

- McCall's Quality Factors
- ISO 9126 Quality Factors
- Targeted Factors

McCall's Quality Factors



ISO 9126 Quality Factors

- **6 quality attributes**:

Reliability : Once a software system is functioning, as specified, and delivered the reliability characteristic defines the capability of the system to maintain its service provision under defined conditions for defined periods of time. One aspect of this characteristic is *fault tolerance* that is the ability of a system to withstand component failure. For example if the network goes down for 20 seconds then comes back the system should be able to recover and continue functioning.

Usability : Usability only exists with regard to functionality and refers to the ease of use for a given function. The ability to learn how to use a system (learnability) is also a major sub-characteristic of usability.

Efficiency : This characteristic is concerned with the system resources used when providing the required functionality. The amount of disk space, memory, network etc. provides a good indication of this characteristic. As with a number of these characteristics, there are overlaps. For example the usability of a system is influenced by the system's Performance, in that if a system takes 3 hours to respond the system would not be easy to use although the essential issue is a performance or efficiency characteristic.

Maintainability : The ability to identify and fix a fault within a software component is what the maintainability characteristic addresses. In other software quality models this characteristic is referenced as supportability. Maintainability is impacted by code readability or complexity as well as modularization. Anything that helps with identifying the cause of a fault and then fixing the fault is the concern of maintainability. Also the ability to verify (or test) a system, i.e. testability, is one of the subcharacteristics of maintainability.

Portability : This characteristic refers to how well the software can adopt to changes in its environment or with its requirements. The sub-characteristics of this characteristic include adaptability. Object oriented design and implementation practices can contribute to the extent to which this characteristic is present in a given system.

- **Functionality:** Functionality is the essential purpose of any product or service. The degree to which the software satisfies stated needs as indicated by the following subattributes – suitabillity, accuracy, interoperability, compliance and security

Targeted Quality Factors

- Intuitiveness : degree to which the interface follows expected usage patterns so that even a novice can use it without significant training.
- Efficiency : degree to which the operations and information can be located or initiated.
- Robustness : degree to which the software handles bad input or inappropriate user interaction.
- Richness : degree to which the interface provides a rich feature set.

The Software Quality Dilemma

- If you produce a software system that has terrible quality, you lose because no one will want to buy it.
- If on the other hand you spend infinite time, extremely large effort, and huge sums of money to build the absolutely perfect piece of software, then it's going to take so long to complete and it will be so expensive to produce that you'll be out of business anyway.
- Either you missed the market window, or you simply exhausted all your resources.
- So people in industry try to get to that magical middle ground where the product is good enough not to be rejected right away, such as during evaluation, but also not the object of so much perfectionism and so much work that it would take too long or cost too much to complete. [Ven03]

"Good Enough" Software

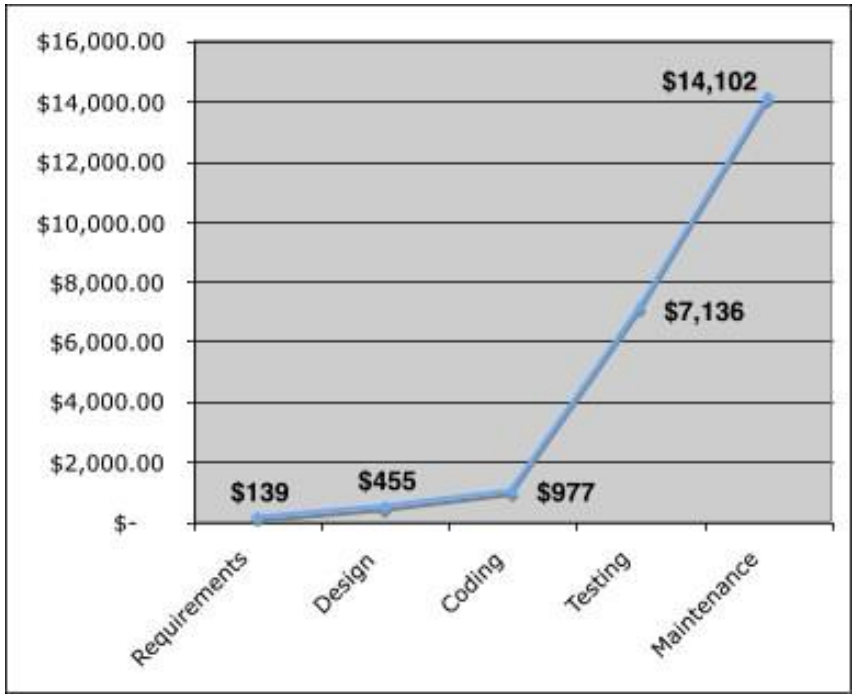
- Good enough software delivers high quality functions and features that end-users desire, but at the same time it delivers other more obscure or specialized functions and features that contain known bugs.
- Arguments *against* "good enough."
  - It is true that "good enough" may work in some application domains and for a few major software companies. After all, if a company has a large marketing budget and can convince enough people to buy version 1.0, it has succeeded in locking them in.
  - If you work for a small company be wary of this philosophy. If you deliver a "good enough" (buggy) product, you risk permanent damage to your company's reputation.
  - You may never get a chance to deliver version 2.0 because bad buzz may cause your sales to plummet and your company to fold.
  - If you work in certain application domains (e.g., real time embedded software, application software that is integrated with hardware can be negligent and open your company to expensive litigation.

Cost of Quality

- *Prevention costs* include
  - quality planning
  - formal technical reviews
  - test equipment
  - Training
- *Internal failure costs* include
  - rework
  - repair
  - failure mode analysis
- *External failure costs* are
  - complaint resolution
  - product return and replacement
  - help line support
  - warranty work

Cost

- The relative costs to find and repair an error or defect increase dramatically as we go from prevention to detection to internal failure to external failure costs.



Quality and Risk

- "People bet their jobs, their comforts, their safety, their entertainment, their decisions, and their very lives on computer software. It better be right."
- Example:
  - Throughout the month of November, 2000 at a hospital in Panama, 28 patients received massive overdoses of gamma rays during treatment for a variety of cancers. In the months that followed, five of these patients died from radiation poisoning and 15 others developed serious complications. What caused this tragedy? A software package, developed by a U.S. company, was modified by hospital technicians to compute modified doses of radiation for each patient.

Negligence and Liability

- The story is all too common. A governmental or corporate entity hires a major software developer or consulting company to analyze requirements and then design and construct a software-based "system" to support some major activity.
  - The system might support a major corporate function (e.g., pension management) or some governmental function (e.g., healthcare administration or homeland security).
- Work begins with the best of intentions on both sides, but by the time the system is delivered, things have gone bad.
- The system is late, fails to deliver desired features and functions, is error-prone, and does not meet with customer approval.
- Litigation ensues.

Quality and Security

- Gary McGraw comments [Wil05]:
- "Software security relates entirely and completely to quality. You must think about security, reliability, availability, dependability—at the beginning, in the design, architecture, test, and coding phases, all through the software life cycle [process]. Even people aware of the software security problem have focused on late life-cycle stuff. The earlier you find the software problem, the better. And there are two kinds of software problems. One is bugs, which are implementation problems. The other is software flaws—architectural problems in the design. People pay too much attention to bugs and not enough on flaws."

Achieving Software Quality

- Critical success factors:
  - Software Engineering Methods
  - Project Management Techniques
  - Quality Control
  - Quality Assurance

Software Quality Assurance

- Elements of SQA:

1. Standards
2. Reviews and Audits
3. Testing
4. Error/defect collection and analysis
5. Change management
6. Education
7. Vendor management
8. Security management
9. Safety
10. Risk management

Role of the SQA Group-I

- **Prepares an SQA plan for a project.**
  - The plan identifies
    - evaluations to be performed
    - audits and reviews to be performed
    - standards that are applicable to the project
    - procedures for error reporting and tracking
    - documents to be produced by the SQA group
    - amount of feedback provided to the software project team
- **Participates in the development of the project's software process description.**
  - The SQA group reviews the process description for compliance with organizational policy, internal software standards, externally imposed standards (e.g., ISO-9001), and other parts of the software project plan.

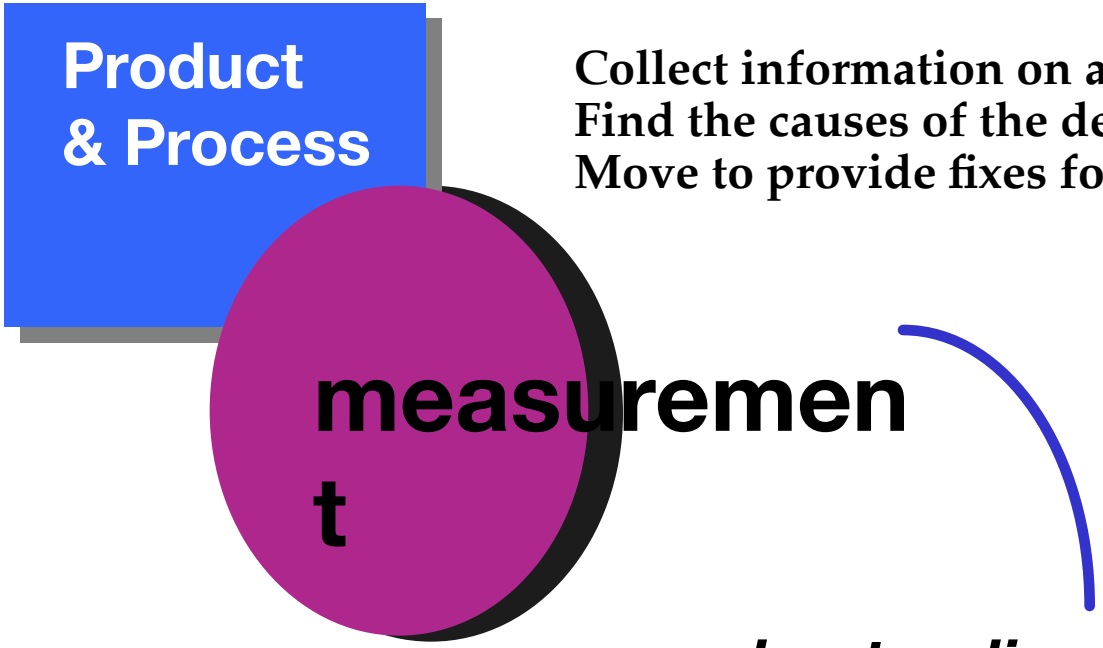
Contd…

- **Reviews software engineering activities to verify compliance with the defined software process.**
  - identifies, documents, and tracks deviations from the process and verifies that corrections have been made.
- **Audits designated software work products to verify compliance with those defined as part of the software process.**
  - reviews selected work products; identifies, documents, and tracks deviations; verifies that corrections have been made
  - periodically reports the results of its work to the project manager.
- **Ensures that deviations in software work and work products are documented and handled according to a documented procedure.**
- **Records any noncompliance and reports to senior management.**
  - Noncompliance items are tracked until they are resolved.

SQA Goals

- **Requirements quality.** The correctness, completeness, and consistency of the requirements model will have a strong influence on the quality of all work products that follow.
- **Design quality.** Every element of the design model should be assessed by the software team to ensure that it exhibits high quality and that the design itself conforms to requirements.
- **Code quality.** Source code and related work products (e.g., other descriptive information) must conform to local coding standards and exhibit characteristics that will facilitate maintainability.
- **Quality control effectiveness.** A software team should apply limited resources in a way that has the highest likelihood of achieving a high quality result.

Statistical SQA



Collect information on all defects
Find the causes of the defects
Move to provide fixes for the process

... an understanding of how to improve quality ...

Statistical SQA

- Information about software errors and defects is collected and categorized.
- An attempt is made to trace each error and defect to its underlying cause (e.g., non-conformance to specifications, design error, violation of standards, poor communication with the customer).
- Using the Pareto principle (80 percent of the defects can be traced to 20 percent of all possible causes), isolate the 20 percent (the *vital few*).
- Once the vital few causes have been identified, move to correct the problems that have caused the errors and defects.

What Are Reviews?

- a meeting conducted by technical people for technical people
- a technical assessment of a work product created during the software engineering process
- a software quality assurance mechanism
- a training ground

What Reviews Are Not

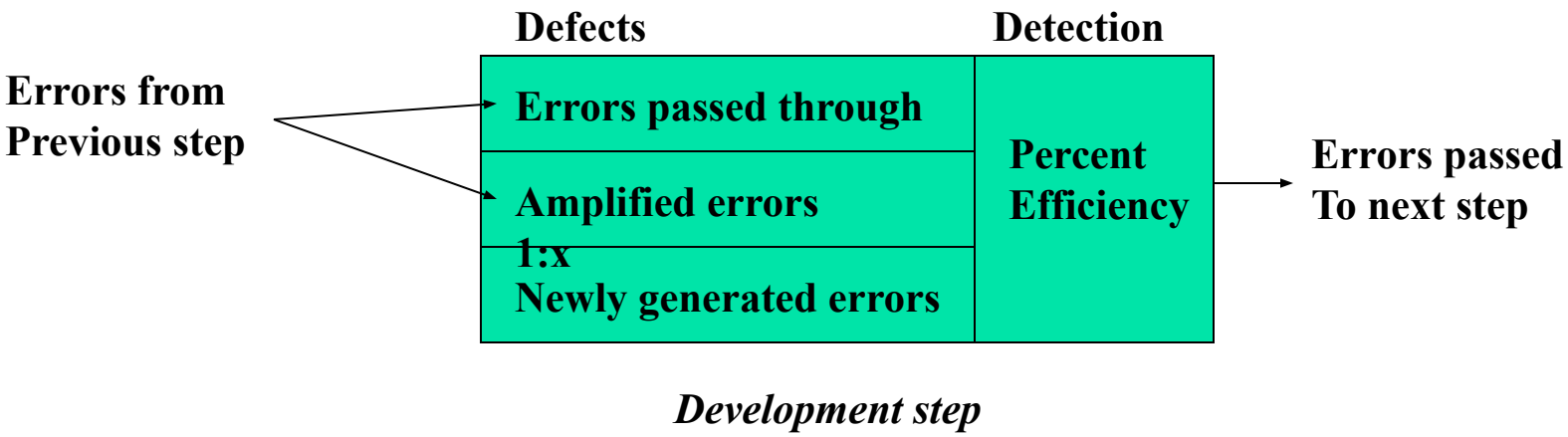
- A project summary or progress assessment
- A meeting intended solely to impart information
- A mechanism for political or personal reprisal!

What Do We Look For?

- Errors and defects
  - *Error*—a quality problem found *before* the software is released to end users
  - *Defect*—a quality problem found only *after* the software has been released to end-users
- We make this distinction because errors and defects have very different economic, business, psychological, and human impact
- However, the temporal distinction made between errors and defects in this book is *not* mainstream thinking

Defect Amplification

- A *defect amplification model* [IBM81] can be used to illustrate the generation and detection of errors during the design and code generation actions of a software process.



Reference Model

Informal Reviews

- Informal reviews include:
  - a simple desk check of a software engineering work product with a colleague
  - a casual meeting (involving more than 2 people) for the purpose of reviewing a work product, or
  - the review-oriented aspects of pair programming
- *pair programming* encourages continuous review as a work product (design or code) is created.
  - The benefit is immediate discovery of errors and better work product quality as a consequence.

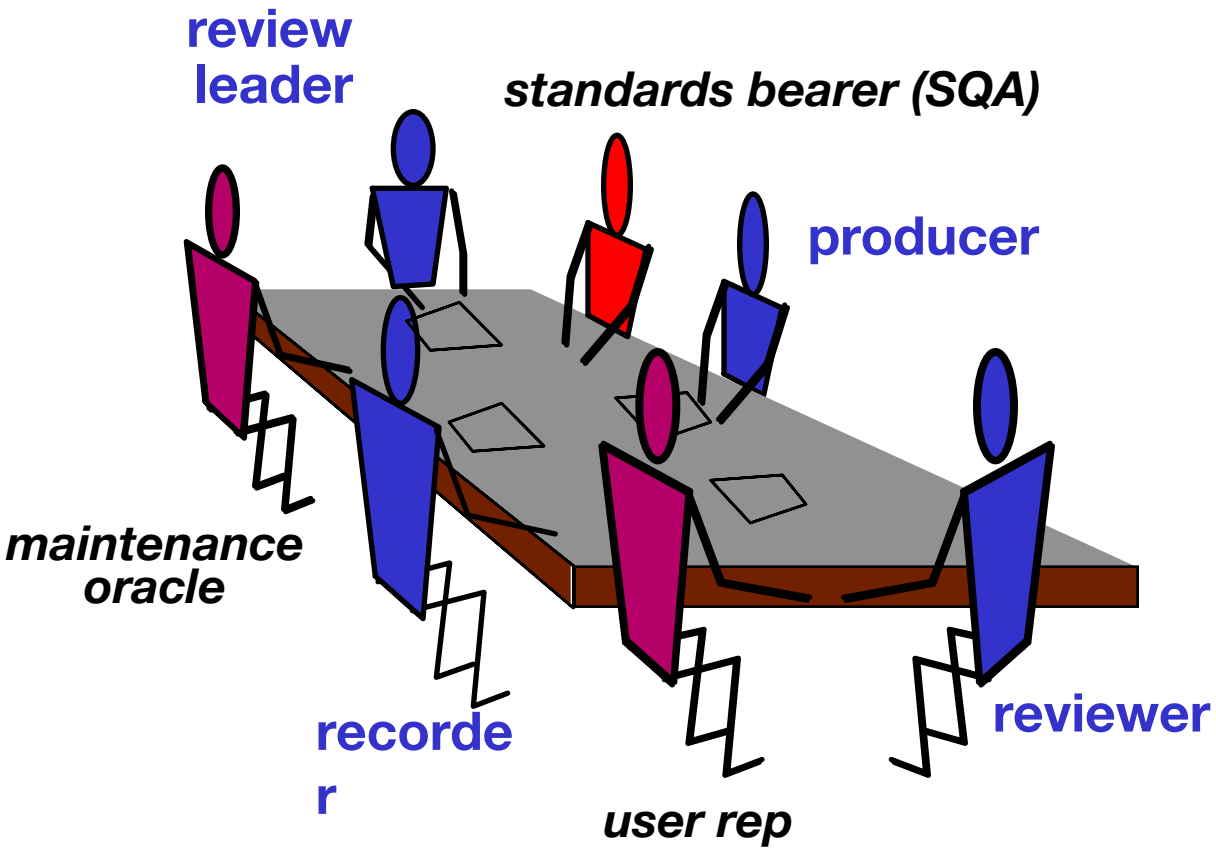
Formal Technical Reviews

- The objectives of an FTR are:
  - to uncover errors in function, logic, or implementation for any representation of the software
  - to verify that the software under review meets its requirements
  - to ensure that the software has been represented according to predefined standards
  - to achieve software that is developed in a uniform manner
  - to make projects more manageable
- The FTR is actually a class of reviews that includes *walkthroughs* and *inspections*.

The Review Meeting

- Between three and five people (typically) should be involved in the review.
- Advance preparation should occur but should require no more than two hours of work for each person.
- The duration of the review meeting should be less than two hours.
- Focus is on a work product (e.g., a portion of a requirements model, a detailed component design, source code for a component)

The Players


review leader
standards bearer (SQA)
producer
maintenance oracle
recorder
user rep
reviewer

The Players

- *Producer*—the individual who has developed the work product
  - informs the project leader that the work product is complete and that a review is required
- *Review leader*—evaluates the product for readiness, generates copies of product materials, and distributes them to two or three *reviewers* for advance preparation.
- *Reviewer(s)*—expected to spend between one and two hours reviewing the product, making notes, and otherwise becoming familiar with the work.
- *Recorder*—reviewer who records (in writing) all important issues raised during the review.

Conducting the Review

- Review the product, not the producer.
- Set an agenda and maintain it.
- Limit debate and rebuttal.
- Enunciate problem areas, but don't attempt to solve every problem noted.
- Take written notes.
- Limit the number of participants and insist upon advance preparation.
- Develop a checklist for each product that is likely to be reviewed.
- Allocate resources and schedule time for FTRs.
- Conduct meaningful training for all reviewers.
- Review your early reviews.

Software Reliability

- A simple measure of reliability is *mean-time-between-failure* (MTBF), where

  MTBF = MTTF + MTTR

- The acronyms MTTF and MTTR are *mean-time-to-failure* and *mean-time-to-repair*, respectively.
- *Software availability* is the probability that a program is operating according to requirements at a given point in time and is defined as

  Availability = [MTTF/(MTTF + MTTR)] x 100%

Software Safety

- *Software safety* is a software quality assurance activity that focuses on the identification and assessment of potential hazards that may affect software negatively and cause an entire system to fail.
- If hazards can be identified early in the software process, software design features can be specified that will either eliminate or control potential hazards.

Six-Sigma for Software Engineering

- The term "six sigma" is derived from six standard deviations—3.4 instances (defects) per million occurrences—implying an extremely high quality standard.
- The Six Sigma methodology defines three core steps:
  - *Define* customer requirements and deliverables and project goals via well-defined methods of customer communication
  - *Measure* the existing process and its output to determine current quality performance (collect defect metrics)
  - *Analyze* defect metrics and determine the vital few causes.
  - *Improve* the process by eliminating the root causes of defects.
  - *Control* the process to ensure that future work does not reintroduce the causes of defects.

ISO 9000

International set ofstandards for quality management

Applicable to a range of organisations from manufacturing to service industries

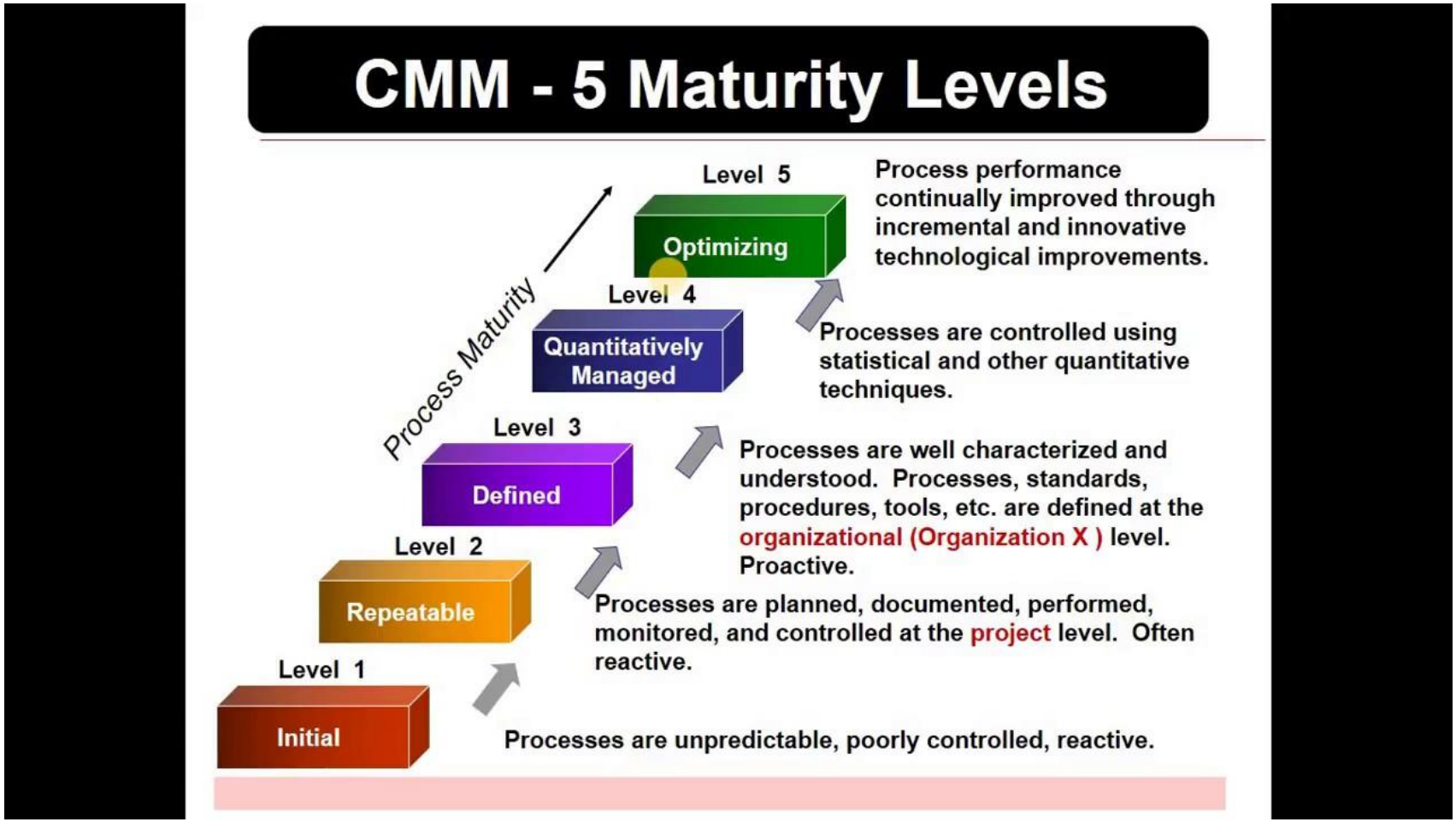
ISO 9001 applicable to organisations which design, develop and maintain products

ISO 9001 is a generic model of the quality process
Must be instantiated for each organisation

ISO 9001:2000 Standard

- ISO 9001:2000 is the quality assurance standard that applies to software engineering.
- The standard contains 20 requirements that must be present for an effective quality assurance system.
- The requirements delineated by ISO 9001:2000 address topics such as
  - management responsibility, quality system, contract review, design control, document and data control, product identification and traceability, process control, inspection and testing, corrective and preventive action, control of quality records, internal quality audits, training, servicing, and statistical techniques.

Capability Maturity Model (CMM)



The SQA Plan

- SQA Plan provides road map for instituting Software quality assurance.
- SQA Plan is the plan developed by the SQA group to guide the organization in SQA activities
- The standard by IEEE for SQA plan recommends a structure that identifies :

1. The purpose and scope of the plan
2. A description of all software engineering work products that fall within preview of SQA
3. All applicable standards and practices that are applied during the software process
4. SQA actions and tasks and their placement throughout the software process.


SQA0
• Review project planning
SQA1
• Review software requirement analysis
SQA2
• Review Test Design
SQA3
• Review before release
SQA4
• Review project closing


Thank you!